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DRAFT TECHNICAL MEMORANDUM OPTIMIZED REMEDIAL ALTERNATIVE FOR PARCEL F

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ECC - INSIGHT, LLC

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Hunters Point Naval Shipyard
San Francisco, California

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Optimized Remedial Alternative for Parcel F

Hunters Point Naval Shipyard, San Francisco, California

PREPARED FOR:	U.S. Department of the Navy Base Realignment and Closure Program Management Office West
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DATE:	May 3, 2017

1.0 Purpose and Introduction

The purpose of this Technical Memorandum (Tech Memo) is to present the approach and rationale for developing an optimized remedial alternative to remediate contaminated sediment within Parcel F (the Site) at Hunters Point Naval Shipyard (HPNS), San Francisco, California, to address the remedial action objectives (RAOs) identified in the Parcel F Final Feasibility Study (FFS) (Barajas and Associates 2008). In addition, the Tech Memo discusses the technology assignment framework criteria proposed to support the development of the optimized alternatives for Parcel F.

A site location map, depicting HPNS, Parcel F, and the various Parcel F sub-areas, is presented as Figure 1. HPNS is a peninsula, approximately 420 acres in size, and juts into San Francisco Bay. Parcel F is the offshore area and consists of approximately 446 acres of underwater property. During Phase 1A and Phase 1B ecological risk assessments (PRC Environmental Management, Inc. 1994, 1996), Parcel F was subdivided into 11 subareas. Based on the numerous investigation results, Area III, Area IX, and Area X of Parcel F were shown to contain chemicals of concern (COCs) at concentrations that posed unacceptable risk and warranted remedial actions as described in the Parcel F validation study report (Battelle, Blasland, Bouck & Lee, Inc. [BBL] and Neptune and Company 2005) and the Parcel F FFS (Barajas and Associates 2008). COCs identified at the site are copper, lead, mercury, and total polychlorinated biphenyls (PCBs).

Area III is located adjacent to Point Avisadero, Area IX (Oil Reclamation Area) is adjacent to Parcel E, and Area X (South Basin) is adjacent to Parcel E-2. RAOs and preliminary remediation goals (PRGs) developed for Parcel F are focused on reducing risks to human health and the environment due to the presence of total PCBs, mercury, and copper within Areas III, IX, and X.

The 2008 FFS developed four remedial alternatives for Area III and six remedial alternatives for Areas IX/X. The FFS evaluated those alternatives with respect to the first seven of the nine National Oil and Hazardous Substances Pollution Contingency Plan (NCP) criteria: two threshold, five primary balancing, and two modifying criteria (Barajas and Associates 2008). Subsequently, additional information has been gathered in support of evaluating and remediating COCs at Parcel F, including the following:

- Field Testing of Activated Carbon Mixing and In Situ Stabilization of PCBs in Sediment (Environmental Security Technology Certification Program [ESTCP] 2008),
- Final Addendum to the Feasibility Study for Parcel F (KCH 2017), and

- Demonstration of Activated Carbon Amendments – Summary of Field Activities Up to the 8-Month Post-Carbon Amendment Placement Monitoring Event (KCH, 2016).

This additional information has been incorporated into the evaluation presented in the FFS for Areas III and IX/X and used to develop an optimized remedial alternative for Areas IX/X. In addition, the performance of the remedial alternatives presented in the FFS have been re-evaluated against the 200 micrograms per kilogram (µg/kg) background near-shore total PCB concentration (on an area-weighted average) developed for San Francisco Bay (Barajas and Associates 2008). The development of the optimized alternative is presented herein along with the rationale for technology selection and screening against the original seven NCP criteria from the FFS, with the addition of a sustainability criterion. In addition, the technology assignment framework presented will determine how the different technologies included in the optimized remedy will be mapped across Areas IX/X. Collectively, this document provides the basis and strategy for developing this optimized alternative. A comparative analysis of the optimized alternative relative to the other six Area IX/X alternatives developed in the FFS will be provided in the upcoming Proposed Plan.

2.0 Preliminary Remediation Goals

As discussed in the FFS, PRGs were developed for Parcel F based on risk assessment results and RAOs. Consistent with United States Environmental Protection Agency (EPA) guidance, RAOs consist of media-specific goals for protecting human health and the environment. RAOs provide a general description of what the cleanup is expected to accomplish and facilitate the development and evaluation of remedial action alternatives in the feasibility study (FS). PRGs represent concentrations in environmental media that are protective of both human and ecological receptors for each RAO.

2.1 Risk Assessment Summary

RAOs were developed in the FFS based on the results of the human health and ecological risk assessments presented in the HPNS validation study (Battelle, BBL and Neptune & Company 2005). The risk assessment characterizes the risks associated with current and reasonably anticipated future exposure at each of three subareas associated with Parcel F. Unacceptable risks identified in the baseline human health and ecological risk assessments are generally the focus of remedial activities.

Unacceptable ecological risks were identified in the validation study at Area III and Areas IX and X to birds feeding on benthic invertebrates and fishes. In Area III, copper and mercury were identified as the primary risk drivers, and PCBs were the primary risk drivers in Areas IX and X (Battelle, BBL and Neptune and Company 2005). A summary of the risks to the surf scoter are summarized in Table 1.

Evaluation of fish tissue in the Validation Study determined that only total PCBs in jacksmelt were present above ambient levels. The human health evaluation similarly concluded that risks to humans from chemicals in Parcel F sediments appear to be similar to risks from ambient conditions with the exception of exposure to PCBs (Battelle, BBL and Neptune and Company 2005). Risks to human health associated with PCBs were highest in Areas IX and X. A summary of total PCB risks are as follows:

- Direct contact risks ranged between 6×10^{-9} and 3×10^{-7}.

- Shellfish consumption risk was estimated at 1×10^{-5}.

- Fish (jacksmelt) consumption risk was estimated at 3×10^{-4}.

The results of the human health risk assessment (HHRA) were updated in the feasibility study (FS) addendum (KCH, 2017), which determined that radiological risk resulting from exposure to Parcel F sediments was within EPA's risk range of 1×10^{-4} to 1×10^{-6} and did not exceed the risk associated with background levels of radionuclides. The risks associated with exposure to chemicals were also revised to reflect updated EPA and California Department of Toxic Substances Control (DTSC) recommendations for exposure point concentrations, exposure factors, toxicity criteria, and mode of action (EPA 2014; DTSC 2014). Key exposure factors that were adjusted include the exposure duration and averaging time for cancer and non-cancer risks, adult body weight, and the cancer slope factor for total PCBs. In addition, non-cancer risk associated with exposure to PCBs was evaluated. The updated risk assessment demonstrated that risks to human health were within EPA's risk range of 1×10^{-4} to 1×10^{-6} under the Reasonable Maximum Exposure scenario, with the exception of arsenic and the shellfish consumption exposure pathway. The risks associated with arsenic were similar to (and actually lower than) the reference area risks (site risk = 2.5×10^{-4}; reference risks = 2.7×10^{-4}). The updated total PCB risks are as follows (Table 2):

- Direct contact cancer risks ranged between 1×10^{-7} and 5×10^{-5}.
- Direct contact hazard quotients ranged between 0.002 and 0.1.
- Shellfish consumption risk ranged between 3×10^{-7} and 8×10^{-6}.
- Shellfish consumption hazard quotients ranged between 0.02 and 0.4.

The FS addendum did not reevaluate risks associated with the fish consumption exposure pathway due to uncertainties associated with the fish consumption pathway, such as the difficulty in linking tissue concentrations in larger sport fish to site-specific sediment concentrations (KCH 2017). However, fish consumption risks associated with PCBs were recalculated in this Tech Memo using the updated exposure factors and the site-wide jacksmelt tissue concentration of 224 µg/kg presented in the 2005 Validation Study. A summary of the updated human health risks are presented in Table 2.

- Fish (jacksmelt) consumption risk was estimated at 9×10^{-5}.
- Fish (jacksmelt) non-cancer hazard quotient was estimated at 8.

2.2 Remedial Action Objectives

Consistent with EPA guidance (EPA 1988), RAOs are intended to provide a general description of the cleanup objectives and provide the basis for the development of specific PRGs. RAOs consist of media-specific goals for protecting human health and the environment that specify COCs for each media of interest; exposure pathways, including exposure routes and receptors; and an acceptable chemical concentration or range of concentrations for each exposure route. RAOs were presented in Section 2 of the FFS based on the results of the final Parcel F validation study (Battelle, BBL and Neptune and Company, 2005), including:

1. Reduce the risk of benthic feeding and piscivorous birds, including surf scoters, to acceptable levels from exposure to copper, lead, mercury, and total PCBs through consumption of contaminated prey and incidental ingestion of sediment.

2. Limit or reduce the potential risk to human health from consumption of shellfish from Parcel F.

3. Limit or reduce the potential biomagnifications of total PCBs at higher trophic levels in the food chain to reduce the potential risk to human health from consumption of sport fish.

2.3 Preliminary Remediation Goals

PRGs were developed on an RAO and COC basis in the FFS (Barajas and Associates 2008). COCs are a subset of the chemicals of potential concern that are to be addressed by the response action. COCs in sediment were identified based on potential risks to human health and the environment. Ecological COCs include copper, lead, mercury, and total PCBs. Human health COCs are limited to PCBs based on the fish and shellfish consumption exposure pathway. PRGs for each RAO are presented in Table 3. A discussion of PRGs for each RAO is summarized below:

RAO 1

The ecological risk assessment presented in the validation study determined that surf scoters in Areas III, IX, and X may be at risk from ingested doses of copper, lead, mercury, and PCBs if the birds obtain more that 50 percent of the daily food intake from these areas. As described in the FFS, PRGs were developed for copper, mercury, and total PCBs based on a site use factor (SUF) of 0.5, meaning that the surf scoter is obtaining half of its intake from these areas.

PRGs for copper, mercury, and total PCBs in sediment were developed in the FFS using the data from collocated sediment and laboratory-exposed *Macoma nasuta* tissue concentrations in a food chain model based on risk to the surf scoter. Specific parameters for each COC are as follows:

- Copper: Using a SUF of 0.5, the RAO 1 copper PRG was estimated at 271 milligrams per kilogram (mg/kg), which is approximately the effects range-median (ER-M) value (270 mg/kg).

- Lead: A numerical RAO 1 PRG was not developed for lead due to uncertainty associated with the bioavailability and toxicity of lead. Because lead is collocated with PCBs in sediment, achieving the remedial goals for PCBs is expected to address any risks associated with lead.

- Mercury: Using a SUF of 0.5, the RAO 1 mercury PRG was estimated at 1.87 mg/kg. A SUF of 0.5 greatly overestimates the actual foraging of the surf scoter in Area III and is thus considered protective.

- PCBs: Using a SUF of 0.5, the RAO 1 PCB PRG was estimated at 1,240 µg/kg. This PRG is considered conservative for Area III since clams are scarce or absent in this area.

RAO 2

Potential human health risks from shellfish consumption and direct contact with sediment during shellfish collection were evaluated using *M. nasuta* tissue data from the laboratory bioaccumulation test to develop the second RAO. Future residents were assumed to harvest and consume shellfish from the intertidal areas of Parcel F and be incidentally exposed to sediment during harvesting. The direct contact exposure scenario associated with harvesting was also assumed to be representative of individuals wading in nearshore areas.

PCBs: Using the risk model developed for the Parcel F validation study (Battelle, BBL and Neptune and Company 2005), a range of PRGs for PCBs was calculated using assumptions appropriate for a shellfish ingestion scenario. PRGs were calculated based on a lifetime cancer risk of 1×10^{-5}, a shellfish consumption rate of 2.13 grams per day (g/day), and an assumption that 10 percent of the clams ingested are obtained from Parcel F. As presented in Table 2-1 of the FFS, the PRG for RAO 2 was established as 1,350 µg/kg as measured on an area-weighted average basis.

RAO 3

Although the HHRA determined that the fish consumption exposure pathway poses unacceptable risks, numerical remediation goals were not developed for RAO 3 as part of the FS due to uncertainties associated with the fish consumption pathway. Key uncertainties include uncertainty in the tissue-sediment relationship and the difficulty in linking tissue concentrations in larger sport fish with large home ranges to site-specific sediment concentrations. In addition, San Francisco Bay is listed as a toxic hot spot under the Bay Protection and Toxic Cleanup Program because of the elevated PCB concentrations in fish tissue caught in the Bay in 1994. Therefore, reduction of PCB concentrations in sport fish caught at Parcel F would depend upon cleanup of sources other than Parcel F and is not within the purview of the Navy.

A risk-based PRG can be developed based on parameters presented in the validation study report (Battelle, BBL and Neptune and Company 2005) and the updated exposure assumptions presented in the FS addendum (KCH 2017). The following presents a proposed risk-based RAO3 sediment PRG for PCBs based on a review of recent project documentation.

Proposed Risk-Based PRG: Calculation of sediment PRGs for RAO 3 requires development of acceptable fish tissue concentrations based on the fish consumption exposure assumptions and development of a tissue-sediment relationship using biota-sediment accumulation factors (BSAFs) or a calibrated, site-specific foodweb model. A BSAF is defined as the ratio of the lipid normalized tissue concentration to the organic carbon normalized sediment concentration:

$$BSAF = \frac{C(tissue, LN)}{C(sediment, OC)}$$

Based on a fish consumption rate of 48 g/day presented in the validation study report (Battelle, BBL and Neptune and Company 2005) and the updated exposure assumptions presented in the FS addendum (KCH, 2017), an acceptable tissue concentration of 255 µg/kg (C[tissue]) can be estimated based on a cancer risk of 1×10^{-4}. In addition, an acceptable tissue concentration based on non-cancer risk of 29.2 µg/kg (C[tissue]) can also be estimated based on a hazard quotient of 1 and the exposure assumptions presented in the FS addendum. Using a nationwide theoretical BSAF of 4.0 for hydrophobic organic chemicals (United States Army Corps of Engineers 2003, Appendix G) and site-specific values for sediment fraction organic carbon (f_{oc}) content and a fish tissue lipid content (% lipid) of 1.2 and 1.7

percent, respectively, a sediment PRG can be estimated based on the acceptable tissue concentration of 255 µg/kg for cancer and 29.2 µg/kg for non-cancer using the following equation:

$$C(sed) = (\left[\frac{C(tissue)}{\%\ lipid}\right] x\ foc)/BSAF$$

This calculation results in a sediment PRG at the 1 x 10^{-4} risk level of 95 µg/kg and a sediment PRG based on a hazard quotient = 1 of 11 µg/kg.

To evaluate the uncertainty in the PRG estimates, a range of site-specific BSAFs were estimated based on a limited jacksmelt and sediment data set collected from within the South Basin in 2001. Site-specific BSAFs were found to range between 4.4 and 13.5. This results in sediment PRGs ranging between 28 and 87 µg/kg at the 1 x 10^{-4} risk level and between 3.2 and 9.9 µg/kg based on a hazard quotient of 1.

Background Considerations: Background refers to constituents or locations that are not influenced by the releases from a site and is usually described as naturally occurring or anthropogenic. Anthropogenic background consists of natural and human-made substances present in the environment as a result of human activities (not specifically related to the Comprehensive Environmental Response, Compensation, and Liability Act [CERCLA] release in question), whereas naturally occurring background are those substances present in the environment in forms that have not been influenced by human activity. Under CERCLA, cleanup levels are not set at concentrations below natural or anthropogenic background levels (EPA 2002). Thus, if a risk-based remediation goal is below background concentrations, the cleanup level for that chemical may be established based on background concentrations (EPA 2005).

In a letter from the San Francisco Water Quality Control Board (Water Board) regarding PCB cleanup goals for Parcel F sediments, a background-based PCB sediment cleanup goal of 200 µg/kg was recommended (Water Board 2003). The proposed background value is based on the Final Report, Existing Data on PCB Concentrations of Nearshore Sediments and Assessment of Data Quality, Clean Estuary Partnership, Project 4.10a (Applied Sciences 2005). Based on an evaluation of nearshore sediments, a background concentration of 200 µg/kg was calculated as a 95 percent upper tolerance limit (UTL). The UTL provides an upper limit at the 95 percent confidence limit of the background population. Consistent with the Parcel F FFS, consideration was given to achieving an area-weighted average total PCB concentration that is consistent with the upper bound near-shore ambient concentration for total PCBs of 200 µg/kg.

3.0 FS Alternatives

The Parcel F FFS (Barajas and Associates 2008) developed and evaluated a series of remedial alternatives to address contaminated sediments in Areas III and IX/X of Parcel F. A summary of the remedial alternatives presented in the FFS is presented below. Cost estimates are taken from the FFS and presented as present value costs using 2006 dollars.

3.1 Area III (Point Avisadero) Alternatives

A summary of the results of the FFS alternative evaluation for Area III is presented in Table 4. A descriptive summary of each alternative is provided below.

Alternative 1 – No Action. The no-action alternative serves as the baseline condition for comparison purposes.

Alternative 2 – Removal/Backfill and Off-Site Disposal. Alternative 2 includes excavation or dredging of sediment above the "not to exceed" PRGs for copper, mercury, and/or PCBs and disposing of the contaminated sediments at an off-site landfill (*see Figure 4-3 of the 2008 FFS*). Removal may require placement of backfill or residual management layers to limit exposure to contaminated material that remains following removal and often requires dewatering prior to transport and disposal. Removal through dredging or excavation is a proven and effective method for removing contaminated material from the environment. However, removal has the potential to release chemicals to the water column and surrounding area and can be complicated by the presence of debris, structures, and other impediments. A double-walled silt curtain potentially could be used to encircle the excavation in areas close to shore to reduce sediment transport to adjacent areas. However, the feasibility of these control measures is uncertain due to strong currents. The estimated cost of Alternative 2 is $12.2 million (2006 US$). Alternative 2 represents the full sediment removal option.

Alternative 3 – Focused Removal/Backfill, Off-Site Disposal, Armored Cap, and Institutional Controls. Alternative 3 represents a combination remedy consisting of focused sediment removal and capping (*see Figure 4-5 of the 2008 FFS*) for contaminated sediment exceeding the PRGs for copper, mercury, and/or PCBs within Area III. The majority of Area III would be capped with a 1.5-foot-thick layer of sand overlain by 6 inches of armor stone for erosion protection. Focused dredging or excavation and off-site disposal of nearshore sediments that are too shallow to be capped are included to prevent the potential loss of shallow water habitat. Capping is a proven and effective technology for managing contaminated sediments in place and has the advantage of fewer short-term impacts than removal. However, capping may have adverse effects on submerged habitat and may limit waterway uses in the vicinity of the cap. Institutional controls will be implemented to protect cap integrity. The estimated cost of Alternative 3 is $10.2 million (2006 US$).

Alternative 3A – Focused Removal/Backfill, Off-Site Disposal, AquaBlok® Cap, and Institutional Controls. Alternative 3A represents a combination remedy identical to Alternative 3 consisting of focused sediment removal and enhanced capping except that an AquaBlok cap, instead of an armored cap, would be placed over the contaminated sediments. AquaBlok is a patented low permeable material that limits transport of chemicals through a cap and prevents exposure to the underlying contaminated sediments. The advantage of the AquaBlok cap is enhanced capping effectiveness although at higher cost. For example, the cost of Alternative 3 was estimated in the FFS as $10.2 million (2006 US$), whereas the cost of Alternative 3A was estimated as $12.6 million (2006 US$).

Alternative 4 – Focused Removal/Backfill, Off-Site Disposal, Modified Armored Cap, and Institutional Controls. Alternative 4 represents a combination remedy similar to Alternative 3, with focused sediment removal and focused capping, except that the capping footprint is limited to areas in less than 30 feet of water (*see Figure 4-7 of the 2008 FFS*). Limiting cap placement to depths less than 30 feet is expected to be protective of surf scoters based on expected foraging depth but would not limit exposure to the benthic community or fish within Area III. The estimated cost of Alternative 4 is $5.8 million (2006 US$).

Alternative 4A – Focused Removal/Backfill, Off-Site Disposal, Modified AquaBlok Cap, and Institutional Controls. Alternative 4A represents a combination remedy identical to Alternative 3A, with focused sediment removal and focused enhanced capping, except that the capping footprint is limited to areas less than 30 feet in depth. As with Alternative 4, limiting cap placement to depths less than 30 feet is expected to be protective of surf scoters based on expected foraging depth but would not limit exposure to the benthic community or fish within Area III. As with Alternative 3A, the AquaBlok cap provides greater effectiveness at greater cost. The cost of Alternative 4 was estimated in the FFS as $5.8 million (2006 US$), whereas the cost of Alternative 4A was estimated as $7.3 million (2006 US$).

3.2 Areas IX/X (Oil Reclamation Area and South Basin) Alternatives

A summary of the results of the alternative evaluation for Areas IX/X is presented in Table 5. A descriptive summary of each alternative is provided below.

Alternative 1 – No Action. The no-action alternative serves as the baseline condition for comparison purposes.

Alternative 2 – Removal/Backfill and Off-Site Disposal. Alternative 2 includes excavation or dredging of sediment above the "not to exceed" PRGs for copper, mercury, and/or PCBs and disposing of the contaminated sediments at an off-site landfill (*see Figure 4-9 of the 2008 FFS*). Removal through dredging or excavation is a proven and effective method for removing contaminated material from the environment. Cofferdams would be used to isolate the removal areas and thus limit the potential release of COCs to the water column and surrounding area and minimize the generation of residuals that will need to be managed. The use of cofferdams can also facilitate the identification and removal of debris that can hinder removal activities. Although the use of cofferdams can facilitate the removal of contaminated sediments, dewatering operations are likely to be costly and technically challenging. Alternative 2 represents the full sediment removal option. The estimated cost of Alternative 2 is $31.6 million (2006 US$).

Alternative 3 – In Situ Stabilization and Institutional Controls. Alternative 3 relies on in situ treatment using granular activated carbon (GAC) physically mixed into the top 1 foot of the sediment bed (*see Figure 4-12 of the 2008 FFS*). Similar to Alternative 2, cofferdams would be used to facilitate placement and mixing of the in situ treatment material. In situ treatment with GAC has the benefit of being cost effective and implementable. Although some disruption of the benthic community will occur during mixing, it is less invasive than remedies that include removal or capping. In addition, these effects can be mitigated by relying on natural mixing through bioturbation. Several field implementation projects have shown that adding up to 4 percent (by weight) GAC to sediment, by gravity settlement and passive mixing into the surficial (bioactive) layer, does not cause unacceptable adverse effects to the benthic community (Interstate Technology & Regulatory Council [ITRC] 2014). The primary disadvantages of in situ treatment using carbon-based amendments are its limited effectiveness in treating metals and its lower effectiveness in areas exposed to strong currents and wave action because the efficacy of in situ treatment works best in low energy environments (ITRC 2014).

In addition, monitoring of remedy performance may require both bulk sediment and pore water monitoring. Alternative 3 represents the full sediment treatment option. The estimated cost of Alternative 3 is $14.4 million (2006 US$).

Alternative 4 – Monitored Natural Recovery and Institutional Controls. Monitored natural recovery (MNR) does not include any active removal, containment, or treatment of contaminated sediments and instead relies on natural processes, such as deposition and dispersion, to reduce COC concentrations within Areas IX/X and institutional controls to limit exposure until such time at which RAOs are met. Reliance on MNR to achieve RAOs has the advantage of lower cost and less disruption than more active remedial approaches. Although the FFS estimated MNR would take 10 years to achieve RAOs, the primary disadvantage is uncertainty regarding the timeframe required to achieve the RAOs. Alternative 4 represents the full sediment MNR option. The estimated cost of Alternative 4 is $2.1 million (2006 US$).

Alternative 5 – Focused Removal/Backfill, Off-Site Disposal, Monitored Natural Recovery, and Institutional Controls. Alternative 5 relies on focused removal of sediment contamination in areas above the "not to exceed" PRGs for copper, mercury, and/or PCBs in surface sediment, defined as less than 1 foot in depth (*see Figure 4-17 of the 2008 FFS*). MNR would be used to reduce chemical concentrations outside this footprint. Sediments would be removed to a depth of 1 foot and backfilled with clean sand or other suitable material to existing grade. As with Alternative 2, cofferdams will be employed to facilitate removal and backfilling activities and limit impacts to the environment during removal. Institutional controls would be utilized to limit activities that would disrupt sediments. This alternative will remove all PCB surface sediment contamination exceeding 750 µg/kg and the vast majority of PCB sediment contamination exceeding 500 µg/kg. MNR would be utilized to further reduce risks to human health and the environment. Alternative 5 represents a combination remedy with targeted removal of sediments to a depth of 1 foot, MNR, and institutional controls. The estimated cost of Alternative 5 is $16.6 million (2006 US$).

Alternative 5A – Focused Removal/Activated Backfill, Off-Site Disposal, Monitored Natural Recovery, and Institutional Controls. Alternative 5A is identical to Alternative 5, with the exception that the clean backfill material would be mixed with GAC to serve as an additional barrier to any potential residual contamination left in place following removal. However, the same limitations on the use of carbon-based amendments as presented in Alternative 3 apply. Alternative 5A represents a combination remedy with targeted sediment removal, MNR, and institutional controls and the use of reactive materials to increase long-term effectiveness and permanence. The estimated cost of Alternative 5A is $21.7 million (2006 US$).

Alternative 6 – Focused Removal/Backfill, Modified Shoreline Removal Backfill, Off-Site Disposal, Monitored Natural Recovery, and Institutional Controls. Alternative 6 includes removal of surface sediments as described in Alternative 5, the targeted removal of nearshore contaminated sediments down to approximately 2.5 feet, MNR, and institutional controls (*see Figure 4-20 of the 2008 FFS*). Removal of shoreline sediments is expected to limit exposures to humans accessing the shoreline. Alternative 6 represents a combination remedy with targeted sediment removal and shoreline removal, MNR, and institutional controls. The estimated cost of Alternative 6 is $16.9 million (2008 US$).

Alternative 6A – Focused Removal/Activated Backfill, Modified Shoreline Removal Backfill, Off-Site Disposal, Monitored Natural Recovery, and Institutional Controls. Alternative 6A is identical to Alternative 6, with the exception that the clean backfill would be mixed with GAC to serve as an additional barrier to any potential residual contamination left in place following removal. However, the same limitations on the use of carbon-based amendments as presented in Alterative 3 apply. Alternative 6A represents a combination remedy with targeted sediment and shoreline removal, MNR, and institutional controls and the use of reactive materials to increase long-term effectiveness and permanence. The estimated cost of Alternative 6A is $22.4 million.

3.3 Summary of Pilot Study Results

A series of field demonstration studies focused on evaluation of in situ treatment of contaminated sediments using carbon-based amendments have been conducted at HPNS. Overall, the results of the field demonstration studies have demonstrated the effectiveness of in situ treatment using carbon-based amendments at reducing the bioavailability of PCBs in sediments at HPNS. As stated previously, GAC has the benefit of being cost-effective and implementable. Although some disruption of the benthic community will occur during mixing, it is less invasive than remedies that include removal or capping. In addition, these effects can be mitigated by relying on natural mixing through bioturbation. Several field implementation projects have shown that adding up to 4 percent (by weight) GAC to sediment, by gravity settlement and passive mixing into the surficial (bioactive) layer, does not cause unacceptable adverse effects to the benthic community (ITRC 2014). The primary disadvantages of in situ treatment using carbon-based amendments include limited effectiveness in treating metals, uncertainty in achieving low cleanup levels for sediments with high concentrations of PCBs, and lower effectiveness in areas exposed to strong currents and wave action. In addition, monitoring of remedy performance may require both bulk sediment and pore water monitoring.

3.3.1 ESTCP Field Study

An initial field study was performed at HPNS between 2005 and 2008. The study field tested two commercially available large-scale mixing technologies (rototiller and slurry injector system) to place regenerated GAC as an in-treatment method for PCB-contaminated sediments. The results are presented in the Department of Defense's ESTCP Cost and Performance Report, Field Testing of Activated Carbon Mixing and In-Situ Stabilization of PCBs in Sediment at Hunters Point Shipyard Parcel F, San Francisco Bay, California, project ER-0510 (ESTCP 2008).

The use of carbon-based amendments as an in situ treatment technology involves mixing amendment into the contaminated sediment, which strongly adsorbs the hydrophobic organic chemicals in the sediment. This strong sorption stabilizes and reduces the bioavailability of hydrophobic organic chemicals, thus, reducing toxicity to benthic organisms and limiting the uptake of hydrophobic organic chemicals into the food web.

The results of the study demonstrated that placement of GAC in PCB-contaminated sediments resulted in more than 95 percent reduced partitioning into the aqueous phase, depending on the GAC dose applied (ESTCP 2008) using both placement methods. The report concluded that in situ treatment may achieve a factor of 10 or more reduction in the bioavailability (or effective concentration) of PCBs in pore water in the field. This finding supports a remedial strategy that relies on dredging and disposal of hot spot areas with high concentrations of PCBs with in situ treatment using GAC of low to mid-range PCB concentrations.

3.3.2 KCH Pilot Study

A subsequent pilot study is currently underway at HPNS. The pilot study is evaluating reductions in bioavailability associated with two commercially available products – AquaGate™+PAC and SediMite™ – applied at an effective carbon dose ranging between 4 and 6 percent by weight in the surface sediment layer. Placement of the treatment material took place in June 2015. Preliminary results based on the baseline and 8-month post placement monitoring event are presented in *Demonstration of Activated Carbon Amendments – Summary of Field Activities Up to the 8-Month Post Carbon Amendment Placement Monitoring Event Hunters Point Naval Shipyard*, San Francisco, California (KCH 2016). The results of the baseline and 8-month monitoring events are summarized below. Additional monitoring events took place in July/August 2016 (14 month) and January/February 2017 (20 month). A final monitoring event is scheduled for June/July 2017 (24 month).

Performance objectives for the study include physical endpoints (amendment placement, distribution, mixing, and stability), chemical endpoints (changes in PCB partitioning and sorption in the presence of the amendment), and biological endpoints (tissue concentrations of chemicals and assessment of benthic community effects following placement).

The treatment area included intertidal and subtidal sediments within Area X of the South Basin offshore of Parcel E-2. The treatment material was placed using a truck-mounted Telebelt conveyor system positioned on a barge. The target placement thickness associated with a 4 to 6 percent by weight carbon dose ranged between 1.2 and 1.8 inches for AquaGate+PAC and 0.5 and 0.8 inches for Sedimite™.

The results of the pilot study confirmed the targeted placement thickness and demonstrated that complete mixing of the treatment material into the sediment bed through bioturbation and physical mixing occurred at 50 percent of the locations sampled. At the remaining sample locations, a distinct amendment layer was observed, indicating that the amendment had not yet become fully mixed into the sediment bed. Subsequent monitoring will continue to monitor the degree of mixing following placement.

Preliminary chemical sampling of the sediments 8 months following placement showed a decrease in bulk sediment concentrations (54 percent for the AquaGate+PAC plot and 63 percent for the Sedimite™ plot). Monitoring continues to evaluate additional reductions in concentrations with treatment due to a combination of dilution associated with the placement material and deposition of cleaner sediment. Declines in porewater were also observed (87 percent for the AquaGate+PAC plot and 81 percent for the Sedimite™ plot). Due to poor survivability of the clams during the baseline monitoring event, it was not possible to measure reductions in benthic tissue concentrations under field conditions. However, laboratory testing showed an approximate 50 percent reduction in clam tissue concentrations.

Evaluation of benthic community health was evaluated using the organism sediment index (OSI), which is calculated based on observations of apparent redox potential discontinuity layer depth, estimated successional stage, gas voids, and apparent dissolved oxygen conditions. The evaluation of benthic community health following initial placement showed that both amendments had a negative effect on benthic community health, with no observable difference in effects between amendments. However, monitoring conducted 8 months following placement showed that the benthic community had recovered with average OSI values of 9 ± 2 for Plot 1 and 9 ± 1 for Plot 2; neither value is significantly different than the site-wide baseline OSI average of 8.

4.0 Optimized Alternative Development

An optimized remedial alternative was developed for comparison to the alternatives presented in the FFS. The optimized alternative will be designed to address all three RAOs presented in the FFS and incorporate in situ treatment of PCB-contaminated sediments in conjunction with targeted removal, capping/backfill of contaminated sediments, MNR, and institutional controls. The goal of the optimized alternative is to minimize the volume of material requiring removal, management, and off-site disposal; minimize short term-impacts during implementation; maximize cost-effectiveness and maximize a sustainable outcome while meeting the threshold criteria of protectiveness and compliance with PRGs. This section presents the remedial technologies developed in the FFS, the technology assignment framework and evaluation to support the development of the optimized alternative, and the refined technology footprints and optimized alternative approach.

4.1 Remedial Technologies Applicable to Areas III, IX, and X

Removal with Backfill: Contaminated sediments will be removed through dredging or excavation, transported to a barge or on-site processing facility for dewatering, and transported to an off-site disposal facility. Following removal of contaminated sediments, backfill will be placed to achieve pre-removal sediment elevations. Because backfill will be obtained from clean sources, the post remediation sediment concentration in areas targeted for removal with backfill are assumed to be zero.

Capping: Capping of contaminated sediments will be accomplished through placement of sand to isolate the contamination with armor stone to limit erosion or AquaBlok. AquaBlok consists of composite-aggregates composed of a central core, clay or clay-size materials, and polymer. Capping is proposed in Area III due to the high currents offshore of Point Avisadero. Capping was not considered for Areas IX/X. Because backfill will be obtained from clean sources, the post remediation sediment concentration in areas targeted for removal with backfill are assumed to be zero.

In situ Treatment: In situ treatment will be accomplished through placement of GAC using a commercially available product such as AquaGate+PAC or Sedimite. In situ treatment is not applicable in Area III due to the high currents offshore of Point Avisadero. For Areas IX/X, a literature review suggests that GAC can reduce the bioavailable fraction of PCBs, as measured through porewater concentrations, by 90 percent (Ghosh et al. 2011; Tomaszewski et al. 2008; Zimmerman et al. 2005). This is comparable to preliminary results for the KCH plot study which showed an 81% to 87% reduction in porewater concentration within the upper 6 cm of the sediment bed 8 months following placement within the SediMite and AquaGate treatment plots respectively. For Areas IX and X, in situ treatment is expected to be accomplished through placement of a 10 to 30 cm sand layer with sufficient reactive material to achieve a carbon content ranging between 2 to 5 percent by weight. This application rate is consistent with other in situ treatment applications (Ghosh et. al., 2011) and will be further refined during development of the Proposed Plan and remedial design. Placement of sand mixed with carbon-based amendments is expected to result in further reductions in COC concentrations. As a result, an assumed 90 percent reduction in surface sediment concentration is assumed to be a conservative estimate of post-RA sediment concentrations.

MNR: Natural recovery processes include chemical transformation, reduction in COC mobility and bioavailability, physical isolation (or burial), and dispersion (Magar et al. 2009). MNR consists of monitoring the natural recovery process to achieve compliance with the RAOs at HPNS Parcel F. Natural recovery processes at HPNS Parcel F primarily involves natural sedimentation that would create a cleaner layer of surface sediment, by burying more contaminated sediments over time. MNR will be applied to areas outside the removal and in situ treatment areas.

Institutional Controls (ICs): Institutional controls are legal and administrative mechanisms used to implement land use and access restrictions. ICs limit the exposure of future landowner(s) and/or user(s) of the property to hazardous substances present on the property; maintain the integrity of the RAs until remediation is complete and remediation goals have been achieved; and ensure containment of hazardous substances remaining on the property in vapors, soils, sediments, or contaminated groundwater after remedial actions have been taken.

4.2 Technology Assignment Framework

A technology assignment framework was used to support the development of the optimized alternative. Specifically, five site-specific factors were evaluated to aid in the selection and footprint refinement of remedial technologies presented in the FS to develop an optimized alternative for integration into the Proposed Plan. The site-specific factors are:

1. COC sediment concentration,
2. Water depth,
3. Hydrodynamics,
4. Natural recovery rate, and
5. Constructability.

These factors are based on presently available data and may be refined during the remedial design after completion of the pilot study. The following subsections evaluate the effectiveness and implementability of the FFS remedial technologies in the context of the site-specific technology assignment factors. These factors will be further refined during remedial design.

4.2.1 Sediment Concentration

The first criterion used to evaluate where different technologies may be applied is the COC sediment concentration. In situ treatment may not be effective at treating high concentrations of PCBs. As is noted in the ESTCP Cost and Performance Report (ESTCP 2008), an approximate 10-fold reduction in effective sediment concentration can be expected for in situ treatment of sediments contaminated with hydrophobic organic chemicals such as PCBs. Based on a not to exceed PRG of 1,240 μg/kg for total PCBs and an expected 90 percent reduction in surface sediment concentration associated with the placement of sand mixed with carbon-based amendments, surface sediment containing total PCBs exceeding 12,400 μg/kg will be excavated. The remaining contaminated sediment exceeding the not to exceed PRG of 1,240 μg/kg for total PCBs would be treated in situ or undergo MNR based on application of the subsequent technology assignment factors. Because in situ treatment is not considered effective in treating metals, this technology will not be applied to contaminated sediments with levels of mercury or copper above the not to exceed thresholds for these COCs.

4.2.2 Water Depth

The second criterion used to evaluate where different technologies may be applied is the water depth to the sediment treatment area. Shallow water is subject to wind- and vessel-generated waves, which may reduce the long-term effectiveness and permanence of in situ treatment. In situ treatment materials may not remain in place over time when subject to these forces. As a result, in situ treatment will not be applied to the intertidal area and will only be applied to subtidal areas (below the low-tide water level).

4.2.3 Hydrodynamics

The third criterion used to evaluate where different technologies may be applied is the hydrodynamics, and specifically the impacts of strong currents and wave action, on the sediment treatment area. Studies conducted at HPNS, found that near-bottom tidal currents on the north side of Point Avisadero (Area III) are strong and will re-suspend loosely consolidated surface sediments. The same study found that residual circulation within the South Basin (Areas IX/X) is weak, and the basin appears to be an area of net sediment accumulation. Therefore, in situ treatment will only be applied to Areas IX/X and not to Area III due to concerns on long-term effectiveness of in situ treatment in Area III.

The hydrodynamic study also found wave action to be the most significant mode of sediment resuspension in the South Basin. In situ treatment within the South Basin can be enhanced by adding a thicker layer of sand or clean soil in the lower isolation layer of the cap as a climate adaptation measure. In addition, climate change vulnerability monitoring can be integrated into the remedial design to evaluate the potential for resuspension of contaminated sediment under more extreme weather/climate scenarios and to ensure sediment resuspension modeling accurately reflects future projected climate change events.

4.2.4 Natural Recovery Rate

The fourth criterion used to evaluate where different technologies may be applied is the natural recovery rate within the sediment treatment area. Natural recovery was only considered for Areas IX/X and was not considered in Area III because the strong currents offshore of Point Avisadero would be expected to limit the effectiveness of MNR in Area III.

Natural recovery was simulated using a simple model that estimates the time required to meet the target concentration within Areas IX/X. Reductions in surface sediment concentrations were estimated using the SEDCAM model (Jacobs et al. 1988). SEDCAM is a mathematical model that assumes that reductions in sediment concentrations are the result of accumulation of sediment particles from outside the South Basin and mixing with the existing sediment bed. Reduction in COC concentrations due to biodegradation or other degradation processes is assumed to be negligible. The SEDCAM model was chosen for the evaluation of MNR since it is a simple, conservative model that relies on empirical data collected at HPNS.

The SEDCAM model estimates sediment concentrations at time *t* based on the following equation:

$$C(t) = C(p) \times (1 - e^{-t(ML/Rs}) + C(0)\ \times\ e^{-t/(\frac{ML}{Rs})}$$

Where:

C(t) = Sediment concentration at time t (µg/kg)

C(p) = Incoming sediment particle concentration of incoming sediment (µg/kg)
C(0) = Initial sediment concentration (µg/kg)
ML = Mixing Depth (centimeters [cm])
Rs = Sediment Deposition Rate (centimeters per year [cm/year])

Based on information presented in the FFS, an incoming sediment particle concentration of 121 µg/kg and sediment deposition rate of 0.5 cm/yr was assumed. Mixing depth is estimated at 4 cm based on the results of the sediment profile image investigation presented in the most recent pilot study report (KCH 2016). The SEDCAM model was used to evaluate reductions in surface sediment concentrations through MNR for the optimized remedial alternative.

4.2.5 Constructability

The fifth criterion used to evaluate where different technologies may be applied is constructability within the sediment treatment area. The remedial footprint will be refined to incorporate constructability considerations (e.g., vicinity to shoreline) and to include the removal of additional sediments along the eastern shoreline of Areas IX/X as appropriate. The constructability criterion results in removal of all nearshore, intertidal sediments and application of in situ treatment to a contiguous band of subtidal sediments that includes small areas of sediments with PCB concentrations below the not to exceed PRG threshold. This will facilitate implementation of the remedy and provide greater overall risk reduction.

4.3 Remedial Footprint Refinement

Remedial footprints presented in the Parcel F FFS were based on bounding the areas with shallow sediment samples that exceeded the not-to-exceed total PRGs established for RAO 1. Evaluation of the remedial footprints presented in the FFS following construction show that remediation of areas exceeding the RAO 1 PRG will result in a total PCB area-weighted average of 52.4 µg/kg in Area III and 386 µg/kg in Area X. Within Area IX, the FFS included limited removal of contaminated sediments along the Parcel E shoreline, which did not appreciably reduce the area-weighted average total PCB concentration.

A refined remedial footprint was developed based on the technology assignment framework presented in Section 4.2. To evaluate post-remedial action sediment concentrations, it is assumed that removed sediments will be covered with clean backfill to the original grade, resulting in a post-remedial action sediment concentration of zero. In situ treatment of contaminated sediment using 10 to 30 cm of sand mixed with carbon-based amendments is expected to result in a 90 percent reduction in surface sediment concentrations. As a result, post-remedial action sediment concentrations were assumed to be 10 percent of the pre-construction sediment concentration. A description of the refined remedial footprints for each are described below.

4.3.1 Refined Remedial Footprint for Area III

Remedial alternatives evaluated for Area III in the Parcel F FFS, focus on removal and capping of contaminated sediments to varying degrees. The alternatives assume that sediments in less than 20 feet of water are too shallow to be capped. In addition, in situ treatment using carbon-based amendments is not expected to be effective due to the high currents offshore of Point Avisadero. Excavation of contaminated sediments in the nearshore area would remove all sediment contamination exceeding the

PRGs followed by backfilling excavated or dredged areas with clean sediment to pre-removal elevations. Under the alternatives with the smallest remedial footprint (Alternative 4/4A), contaminated sediments in less than 30 feet of water would not be remediated because the area-weighted average PCB concentration is estimated as 52.4 µg/kg. As a result, further optimization of the remedial footprint within Area III is not considered necessary. The remedial footprint for Area III is presented in Figure 2.

4.3.2 Refined Remedial Footprint for Area IX

RAO 1 PRGs are not exceeded with Area IX. However, based on the technology assignment framework described above, the refined alternative will include limited removal of intertidal sediments exceeding 700 µg/kg along the Parcel E shoreline followed by placement of backfill, resulting in an estimated post construction surface sediment PCB concentration of approximately 260 µg/kg. The optimized remedial footprint, showing limited removal followed by backfill of nearshore intertidal sediments within Area IX, is presented in Figure 3. Based on the results of the SEDCAM model, natural recovery will reduce surface sediment concentrations to below 200 µg/kg within 5 years. The results of the SEDCAM Model for Area IX are presented in Figure 4. Copper and mercury will not require remediation within Area IX because the RAO 1 PRGs are not exceeded within Area IX.

The refined remedial footprint for Area III is based on the technology assignment framework presented in Section 4.2 and is considered sufficient for an FS level evaluation. However, the precise remedial footprint and application of remedial technologies will be finalized during remedial design.

4.3.3 Refined Remedial Footprint for Area X

RAO 1 PRGs for metals are not exceeded in Area X. As a result, sediment remediation will focus on total PCBs. Sediments with total PCBs exceeding the RAO 1 PRG will be remediated to address ecological risks. Based on the technology assignment framework described above, intertidal sediment exceeding 700 µg/kg will be removed followed by placement of backfill while subtidal sediments exceeding 700 µg/kg will have in situ treatment with carbon-based amendments. The technology assignment evaluation concluded the removal of all subtidal sediments, including those along the northern shoreline of Area X, and increased application of in situ treatment of subtidal sediments as an optimized remedy component. Based on the refined remedial footprint, the post construction surface sediment PCB sediment concentration is estimated at approximately 300 µg/kg. The optimized remedial footprint, showing removal followed by placement of backfill of nearshore intertidal sediments with in situ treatment of subtidal sediments, is presented in Figure 3. Based on the results of the SEDCAM model, natural recovery will reduce surface sediment concentrations to below 200 µg/kg within 7 years. The results of the SEDCAM Model for Area X is presented in Figure 5.

The refined remedial footprint for Area III is based on the technology assignment framework presented in Section 4.2 and is considered sufficient for an FS level evaluation. However, the precise remedial footprint and application of remedial technologies will be finalized during remedial design.

4.3.4 Area IX/X Removal Depth

Removal depths evaluated in the Parcel F FFS ranged between 1 and 5 feet for Area IX/X, depending on remedial alternative and location. For the optimized alternative, removal depth is estimated to be 1 foot. Based on information presented in the Parcel F FFS, sediments below 1 foot are expected to remain stable in the environment and would not be significantly affected by bioturbation, tides, or erosion from waves and currents generated during storm events. Evaluation of sediment cores presented in the Parcel F FFS suggests little evidence of past erosion, and the sediment stability analysis predicts that scour depths of less than 10 cm (0.32 feet) would occur during storm events. In addition, a stiff layer of clay has been identified at a depth of approximately 1 foot below the sediment surface within Area IX/X that is expected to resist erosion even under high-shear stress conditions. The final removal depth will be determined during remedial design based on a 100-year storm event. In addition, resiliency best management practices (BMPs) (e.g., cap enhancement and vulnerability monitoring) will be integrated into the design to address cap disturbance due to increased wave action.

4.3.5 Monitoring

Monitoring will include construction monitoring, performance monitoring, and long-term effectiveness monitoring. Construction monitoring will include bathymetric surveys prior to and following construction activities to confirm removal depth and backfill and in situ treatment placement. Bucket surveys will be conducted to verify the depth and type of material placed. Performance monitoring will include bulk sediment monitoring of COCs to confirm that the sediment-based goals have been met on a not to exceed and an area-weighted average basis. Bulk sediment monitoring will focus on copper, lead, mercury, and total PCBs measured as total PCB congeners. Because post-construction conditions will include the placement of clean fill and placement of carbon-based amendments mixed with sand, reductions in bulk sediment concentrations are expected. Additional monitoring may include porewater monitoring for total PCBs in areas where carbon amendments are placed and clam tissue monitoring to measure reductions in bioavailability. Porewater-based targets will be estimated based on background sediment concentrations and partitioning theory, according to the following formula:

$$C(pw) = C\,(sed)/(foc \times Koc)$$

Where C(sed) = Background sediment concentration (200 µg/kg)

foc = Average organic carbon content (1.2 percent)

Koc = Total PCB organic carbon partition coefficient (7.8×10^4 liters per kilogram [L/kg]) *

C(pw) = Estimated background porewater concentration (0.21 micrograms per Liter [µg/L])

* Total PCB Koc from EPA Region 3 – Regional Screening Level (RSL) Chemical-Specific Parameters Supporting Table, May 2016 (EPA 2016).

In addition, once the remedy has been implemented, continuous climate change monitoring can be performed to periodically re-evaluate the sediment remediation system's vulnerability and incorporate additional adaptation measures as needed. In Areas IX/X, wave action contributes the most toward resuspension of sediment. Continuous monitoring of surface water flow and wave action should be integrated into the remedial design as a resiliency BMP to ensure sediment resuspension modeling accurately reflects current (future) conditions. Vulnerability monitoring data can also be used in conjunction with site inspection observations to determine if climate change impacts are compromising the integrity of the remedy, thus, prompting consideration of precautionary measures (e.g., engineering controls and cap reinstallation). Periodic vulnerability monitoring should be presented in the Proposed Plan and carried through to the remedial design.

5.0 Evaluation of Optimized Alternative

The optimized alternative is evaluated herein against the NCP criteria. In addition, the evaluation includes a green and sustainable remedy evaluation.

5.1 Evaluation Criteria

The optimized alternative is evaluated in the following subsection against the criteria described below. Note that the evaluation of Modifying Criteria is conducted in the Record of Decision (ROD).

Threshold Criteria:

<u>Overall Protection of Human Health and the Environment</u>: This evaluation criterion provides a final assessment as to whether each alternative provides adequate protection of human health and the environment. This criterion describes how risks associated with each exposure pathway would be eliminated, reduced, or controlled through application of the remedial technologies. Evaluation of protectiveness will include an evaluation of the remaining sediment COC concentrations and associated risk at the completion of construction and the degree of confidence that natural recovery will be successful in reducing COC concentrations to the remedial goals.

<u>Compliance with ARARs</u>: This evaluation criteria assesses whether each alternative meets the applicable or relevant and appropriate federal and state requirements (ARARs) for all of the chemical-specific, location-specific, and action-specific ARARs presented in Section 2.2 and Appendix B of the Parcel F FFS.

Balancing Criteria

<u>Long-Term Effectiveness and Permanence</u>: This evaluation criterion evaluates the long-term effectiveness of each alternative in maintaining reliable protection of human health and the environment over time. This criterion will evaluate the magnitude of residual risk that will remain on site following remediation and the adequacy and reliability of engineering controls and institutional controls to effectively manage those risks posed by treatment residuals and/or untreated wastes remaining at HPNS over time. In addition, the criterion evaluates climate adaptation measures that can be integrated into the remedial design to maximize long-term resiliency of the remedial system.

<u>Reduction of Toxicity, Mobility, and Volume through Treatment</u>: CERCLA expresses a preference for remedial alternatives employing treatment technologies that permanently and significantly reduce the toxicity, mobility, or volume of hazardous substances as their principal element. This evaluation criterion will focus on in situ treatment of contaminated sediments and the use of any reactive materials within backfill material.

<u>Short-Term Effectiveness</u>: Short-term effectiveness addresses the time needed to implement the remedy and any adverse impacts that may be posed to the community, workers, and the environment during construction and operation of the remedy until PRGs and RAOs are achieved. This criterion will evaluate risks to workers and the community associated with removal, transport and disposal of contaminated sediments, and placement of backfill and treatment material. The evaluation will also consider controls to mitigate environmental impacts, including the use of silt curtains and sheet pile walls to minimize releases to the environment during implementation. Time to achieve protection will be based on an evaluation of the ability of MNR to achieve the RAOs for the Site.

Implementability: This criterion will evaluate the technical and administrative feasibility of implementing each alternative and the availability of various services and materials. Metrics used to evaluate the relative magnitude of technical and administrative implementability of each alternative include the area and volume of material requiring remediation since areas and volumes managed are considered proportional to the degree of implementation difficulty. Acreage subject to MNR is also considered because it requires significant administrative effort over the long term to oversee and coordinate sampling and data evaluation as part of long-term monitoring.

Cost: This criterion evaluates the capital and operation and maintenance costs of each alternative. Costs will be evaluated consistent with the methodology presented in Appendix D of the Parcel F FFS as part of the Proposed Plan.

Additional Evaluation

Sustainability: A Green and Sustainable Remediation (GSR) assessment will be performed on the alternatives presented in the Parcel F FFS and the optimized alternative. The objective of the GSR evaluation will be to identify remedial components of the alternatives that are major contributors to environmental, socio-economic, and community impacts and will be used to qualitatively evaluate sustainable benefits from the optimized remedy in the Proposed Plan.

Modifying Criteria

State Acceptance: This criterion provides the government of the state where the project is located with the opportunity to assess technical or administrative issues and concerns regarding each of the alternatives. This criterion will be addressed in the ROD based on comments received on the Proposed Plan.

Community Acceptance: This criterion reflects the community's preferences among or concerns about each alternative. The alternatives evaluated in the FFS and the preferred remedy that will be identified in the Proposed Plan will be presented to the public. Based on comments received during the public comment period, community acceptance will be considered and addressed in the ROD. Issues raised by the community will be discussed and addressed in the Responsiveness Summary Section of the ROD.

5.2 Detailed Analysis of Optimized Alternative

This section provides detailed analysis of the optimized alternative.

Overall Protection of Human Health and the Environment

This alternative would provide protection of human health and the environment. In the intertidal area, excavation or dredging would permanently remove sediments with concentrations exceeding the RAO 1 PRG from Areas IX/X. It is assumed that this will result in a 100% reduction in surface sediment total PCB concentrations. In the remaining subtidal area exceeding the RAO 1 PRG, in situ treatment would be conducted. It is assumed for costing and evaluation purposes that 10 to 30 cm of sand mixed with carbon-based amendments to achieve a carbon content of 2 to 5% would be emplaced, resulting in an estimated 90 percent reduction in surface sediment total PCB concentrations with the final specifications being developed during remedial design. Following construction, MNR would then be expected to reduce area-weighted average concentrations to below PRGs within approximately 7 years (per the SEDCAM model). Institutional and engineering controls would be used to limit access to the site during the natural recovery period.

Compliance with ARARs

This alternative would be designed and implemented in compliance with chemical-, location-, and action-specific ARARs.

Long-Term Effectiveness and Permanence

Magnitude of Residual Risk – This alternative is designed to achieve PRGs, with residual risk at or below San Francisco Bay background. The success of this alternative in achieving long-term effectiveness and permanence primarily depends on the ability to distribute the in situ treatment amendment evenly within the treatment zone and for the mechanisms for MNR (e.g., a sustained sediment deposition rate and sustained mixing of existing and newly deposited sediments) to continue unabated. For the removal zone, backfilling would limit residual risk. Furthermore, based on information in the Parcel F FFS the deeper, unexcavated sediments in the removal zone are expected to be resistant to erosion even under high shear-stress conditions.

Adequacy of Controls – The in situ treatment process and natural recovery process are not reversible. Institutional controls would prevent exposure to contaminated sediment during remedy implementation. The long-term monitoring program and five-year review would assess the performance of removal and in situ treatment as well as natural recovery. These controls are expected to be adequate.

Reliability of Controls – Institutional controls and monitoring for natural recovery are considered reliable methods for ensuring achievement of RAOs.

Resiliency – Continuous climate change monitoring can be performed to periodically re-evaluate the sediment remediation system's vulnerability to climate change impacts, including surface water flow and wave action. Vulnerability monitoring data will be used in conjunction with site inspection observations to determine if climate change impacts are compromising the integrity of the remedy, thus, prompting consideration of precautionary measures (e.g., engineering controls and cap reinstallation).

Reduction of Toxicity, Mobility, or Volume through Treatment

This alternative would reduce toxicity, mobility, and volume of hazardous substances through treatment. Removal would reduce the volume of contamination at the site, and backfilling would reduce mobility of any newly exposed residual contamination. The addition of GAC for the in situ treatment of sediments would reduce toxicity by sequestering PCBs in the activated carbon matrix. This partitioning of the COCs from porewater into the activated carbon solids would also reduce mobility since solids are less mobile than water.

Short-Term Effectiveness

This alternative would have short-term impacts on the order of months due primarily to the operation of heavy equipment for the sediment removal in the intertidal zone and the implementation of the in situ treatment. Engineering controls would be established to minimize the impact while the use of personal protective equipment by workers would minimize exposure.

Implementability

Removal: Sediment removal, dewatering, off-site disposal, and backfilling has been successfully implemented at multiple sites. Successful implementation for sediment removal frequently hinges on the ability to control turbidity and resuspension as well as successful dewatering. Accessibility and suitable lay-down areas are also likely not an implementability concern considering the open space surrounding the site.

In situ treatment: Dispersal of the amendment likely would be done by barge given the distances of the treatment zone from the shoreline. Water depths are sufficient for barge access, and therefore, no significant implementability concerns are associated with in situ treatment.

MNR: No implementability challenges for monitoring of natural recovery are anticipated.

Cost

A cost estimate for the optimized remedial alternative will be developed in the Proposed Plan in accordance with the procedures utilized in the Parcel F FFS. The cost evaluation will be used to demonstrate that the optimized remedial alternative is cost-effective based on an evaluation of cost and overall effectiveness (long-term effectiveness and permanence; reduction in toxicity, mobility, and volume through treatment; and short-term effectiveness).

Sustainability

Remedial components that are considered primary contributors to the environmental footprint will be evaluated and presented as part of the Proposed Plan. These components are associated with amendment materials and fuel consumption during equipment use and residual handling. Detrimental impacts to the surrounding community, primarily attributed to residual handling, will also be evaluated. Areas targeted for active remediation through capping and/or dredging for a multi-component remedy were refined to maximize MNR and in situ treatment as well as minimize removal volume and capping footprint while meeting RAOs. Refinement of the conceptual site model and treatment zones ultimately will result in sustainable benefits that will be quantified in the Proposed Plan.

6.0 Summary

Area III:

Based on the sediment concentration criteria of the technology assignment framework, Alternative 4/4A achieves the RAOs established for the site. In addition, it achieves total PCB concentrations less than background levels on an area weighted basis post-remedial action based on available data. As a result, further optimization of the remedial footprint within Area III is not considered necessary. Incorporation of additional sustainability elements will be considered in the Proposed Plan and during remedial design.

Areas IX/X:

An optimized remedial alternative that incorporates a combination of in situ treatment, removal with backfill and MNR was developed for Areas IX and X based on application of the technology assignment framework presented in Section 4.2. Application of the technology assignment framework results in the remediation of sediments with a surface sediment total PCB concentration above 700 µg/kg resulting in an area weighted average total PCB concentration of approximately 260 µg/kg for Area IX and 300 µg/kg for Area X. The results of the SEDCAM model show that surface sediments within Areas IX and X will reach the background concentration of 200 µg/kg on an area-weighted average within 5 and 7 years, respectively. The detailed analysis of the optimized alternative demonstrates that the optimized remedial alternative will achieve the RAOs established for the site and are in compliance with NCP evaluation criteria. A cost evaluation and GSR assessment of the optimized remedy will be presented in the Proposed Plan.

In addition, the results of the GSR assessment identified sustainable and resilient BMPs that can be implemented to reduce unsustainable impacts during remedy implementation, including lower footprint consumables, clean diesel or engine retrofits, beneficial sediment reuse, optimization of engineering controls, climate change adaptation measures (i.e., cap enhancement and amendment settling enhancement), and continuous vulnerability monitoring of tidal currents, surface water flow velocity, and wave action. These BMPs will be summarized in the Proposed Plan and integrated into the remedial design.

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Tables

Table 1 – Ecological Risk Assessment Summary
Risk Drivers

Chemical	Receptor	Area				
		I	III	VIII	IX	X
Copper	Surf Scoter	0.5	3	0.7	0.7	0.8
Mercury	Surf Scoter	0.3	4	0.3	0.3	0.3
Total PCBs	Surf Scoter	0.1	0.3	0.2	1	2

Acronyms:

PCBs – polychlorinated biphenyls

Table 2 – Updated Human Health Risk Assessment Summary
Risk Drivers

Chemical	Exposure Pathway	Area				
		I	**III**	**VIII**	**IX**	**X**
Excess Lifetime Cancer Risk						
Total PCBs	Direct Contact Sediment	*3.E-06*	5.E-07	9.E-07	1.E-07	*5.E-05*
Total PCBs	Shellfish Consumption	3.E-07	4.E-07	7.E-07	*6.E-06*	*8.E-06*
Total PCBs	Fish Consumption	*9.E-05*				
Non-Cancer Hazard Quotient						
Total PCBs	Direct Contact Sediment	0.006	0.1	0.002	0.02	0.1
Total PCBs	Shellfish Consumption	0.02	0.04	0.06	0.2	0.4
Total PCBs	Fish Consumption	**8**				

Italic: Exceeds cancer risk of 1 x 10^{-6}
Bold: Exceeds cancer risk of 1 x 10^{-4} or Hazard Quotient of 1

Acronyms:
PCBs – polychlorinated biphenyls

Table 3 – Preliminary Remediation Goal Summary

RAO	Copper (mg/kg)	Lead* (mg/kg)	Mercury (mg/kg)	Total PCBs (µg/kg)	Basis
RAO 1	271	NA	1.87	1240	Not to exceed threshold
RAO 2	NA	NA	NA	1350	Area-weighted average
RAO 3	NA	NA	NA	**	Area-weighted average

* A numerical PRG was not developed for lead due to uncertainty associated with the bioavailability and toxicity of this analyte. Because lead is collocated with PCBs in sediment, achieving the remedial goals for PCBs is expected to address any risks associated with lead.

** Sediment exceeding 700 µg/kg will be targeted for remediation within Areas IX and X. 200 µg/kg total PCBs represents a long-term goal based on background total PCB estimates for nearshore sediments within San Francisco Bay.

Acronyms:

mg/kg – milligrams per kilogram
NA – not applicable
µg/kg – micrograms per kilogram
PCBs – polychlorinated biphenyls

Table 4 – Area III Alternatives Evaluation Summary

Alternative	Overall Protection of Human Health and the Environment	Compliance with ARARs	Long-Term Effectiveness and Permanence	Reduction in Toxicity, Mobility, or Volume through Treatment	Short-Term Effectiveness	Implementability	Cost ($M)
No Action	Not protective	Does not comply with ARARs	Low	Low	Low	High	$0
Alternative 2 – Removal and Backfill and Off-Site Disposal	Protective	Complies with ARARs	Low-Medium	Low	Low-Medium	Medium	$12.2
Alternative 3 - Focused Removal and Backfill, Off-Site Disposal, Armored Cap, and ICs	Protective	Complies with ARARs	Medium-High	Low	Medium	Medium	$10.2
Alternative 3A - Focused Removal and Backfill, Off-Site Disposal, AquaBlok Cap, and ICs	Protective	Complies with ARARs	Medium-High	Low	Medium	Medium	$12.6
Alternative 4 - Focused Removal and Backfill, Off-Site Disposal, Modified Armored Cap, and ICs	Protective	Complies with ARARs	Medium	Low	Medium-High	Medium-High	$5.8
Alternative 4A - Focused Removal and Backfill, Off-Site Disposal, Modified AquaBlok Cap, and ICs	Protective	Complies with ARARs	Medium	Low	Medium-High	Medium-High	$7.3

Table 5 – Area IX/X Alternatives Evaluation Summary

Alternative	Overall Protection of Human Health and the Environment	Compliance with ARARs	Long-Term Effectiveness and Permanence	Reduction in Toxicity, Mobility, or Volume through Treatment	Short-Term Effectiveness	Implementability	Cost ($M)
Alternative 1 - No Action	Not protective	Does not comply with ARARs	Low	Low	Medium	High	$0
Alternative 2 - Removal/Backfill and Off-Site Disposal	Protective	Complies with ARARs	Medium	Low	Low-Medium	Medium	$31.6
Alternative 3 - In Situ Stabilization (Treatment) and ICs	Protective	Complies with ARARs	Low	Medium-High	Medium	Medium	$14.4
Alternative 4 - MNR and ICs	Protective	Complies with ARARs	Low-Medium	Low	Medium	Medium-High	$2.1
Alternative 5 - Focused Removal and Backfill, Off-Site Disposal, MNR, and ICs	Protective	Complies with ARARs	High	Low	Medium-High	Medium	$16.6
Alternative 5A Focused Removal and Activated Backfill, Off-Site Disposal, MNR, and ICs	Protective	Complies with ARARs	High	Medium	Medium-High	Medium	$21.7
Alternative 6 - Focused Removal and Backfill, Modified Shoreline Removal/Backfill, Off-Site Disposal, MNR, and ICs	Protective	Complies with ARARs	High	Low	High	Medium	$16.9
Alternative 6A - Focused Removal and Activated Backfill, Modified Shoreline Removal/Backfill, Off-Site Disposal, MNR, and ICs	Protective	Complies with ARARs	High	Medium	High	Medium	$22.4
Optimized Alternative	Protective	Complies with ARARs	High	High	High	Medium	TBD

Figures

Legend

- Navy Property Boundary
- Parcel F Subareas - Hunters Point Naval Shipyard
- Parcel Boundary
- Bathymetry Contour (Depth in meters Referenced to MLLW)

Notes:
MLLW - mean lower low water

N

1,000 0 1,000
Feet
1 inch = 1,000 feet

CDM Smith
ECC INSIGHT LLC

Hunters Point Naval Shipyard, San Francisco, California
U.S. Department of the Navy, BRAC PMO West

Figure 1
Parcel F Subareas

Alternative 4/4A: Focused Removal / Backfill, Off-Site Disposal and Capping to a Depth of 30 feet
PCB Removed: 473 kilograms

Legend

- Navy Property Boundary
- Parcel Boundary
- Parcel F Subarea - Hunters Point Shipyard
- Removal to Labeled Depth Below Sediment Surface
- Cap
- Riprap

200 100 0 200
Feet
1 inch = 200 feet

Hunters Point Naval Shipyard, San Francisco, CA
U.S. Department of the Navy, BRAC PMO West

Figure 2
Remedial Footprint
Optimized Alternative Area III

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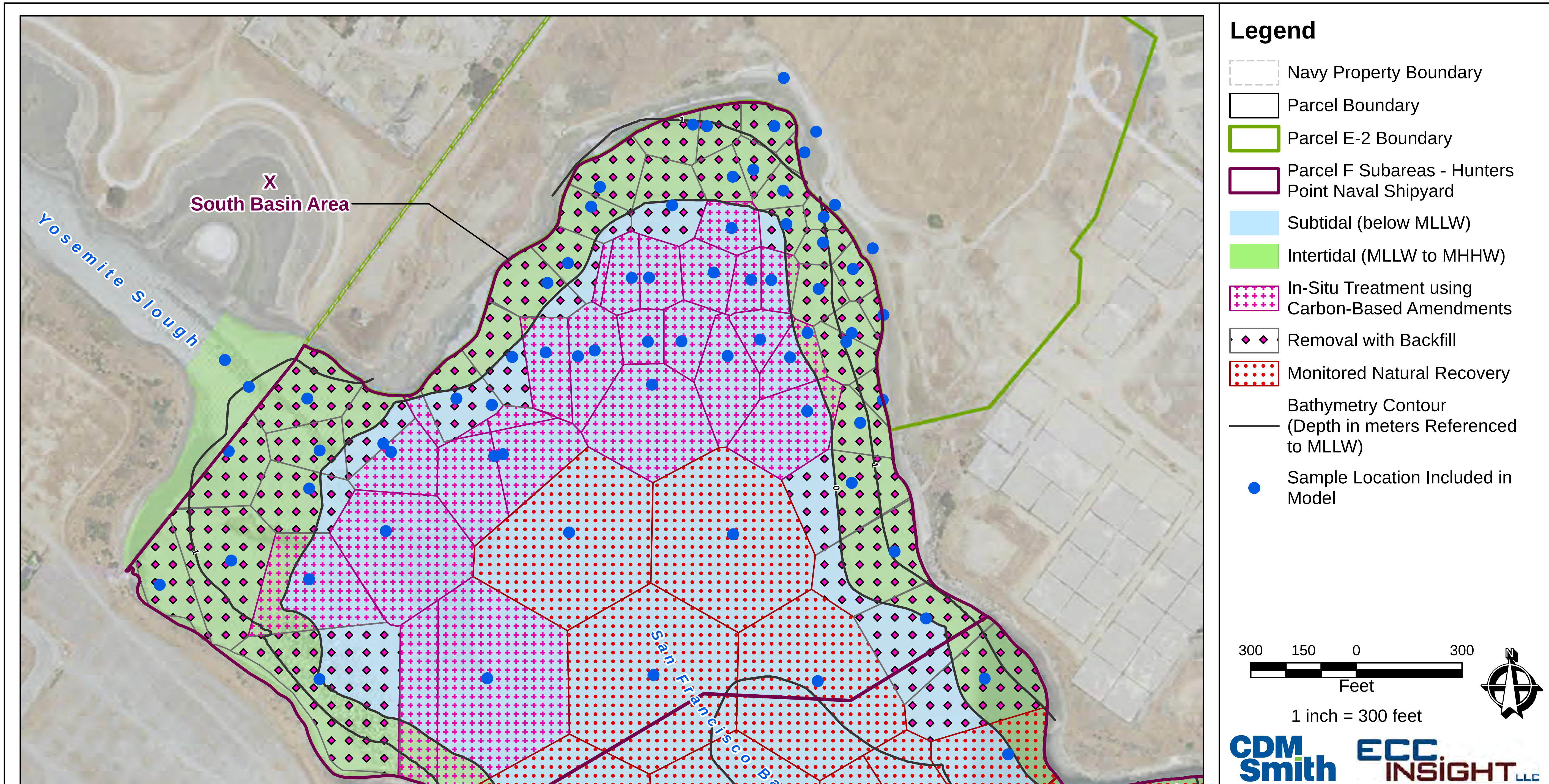

Hunters Point Naval Shipyard, San Francisco, California
U.S. Department of the Navy, BRAC PMO West

Figure 3
Remedial Footprint
Optimized Alternative, Areas IX/X

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Figure 4
Reduction in HPNS Sediment PCB Level due to MNR (Area IX)

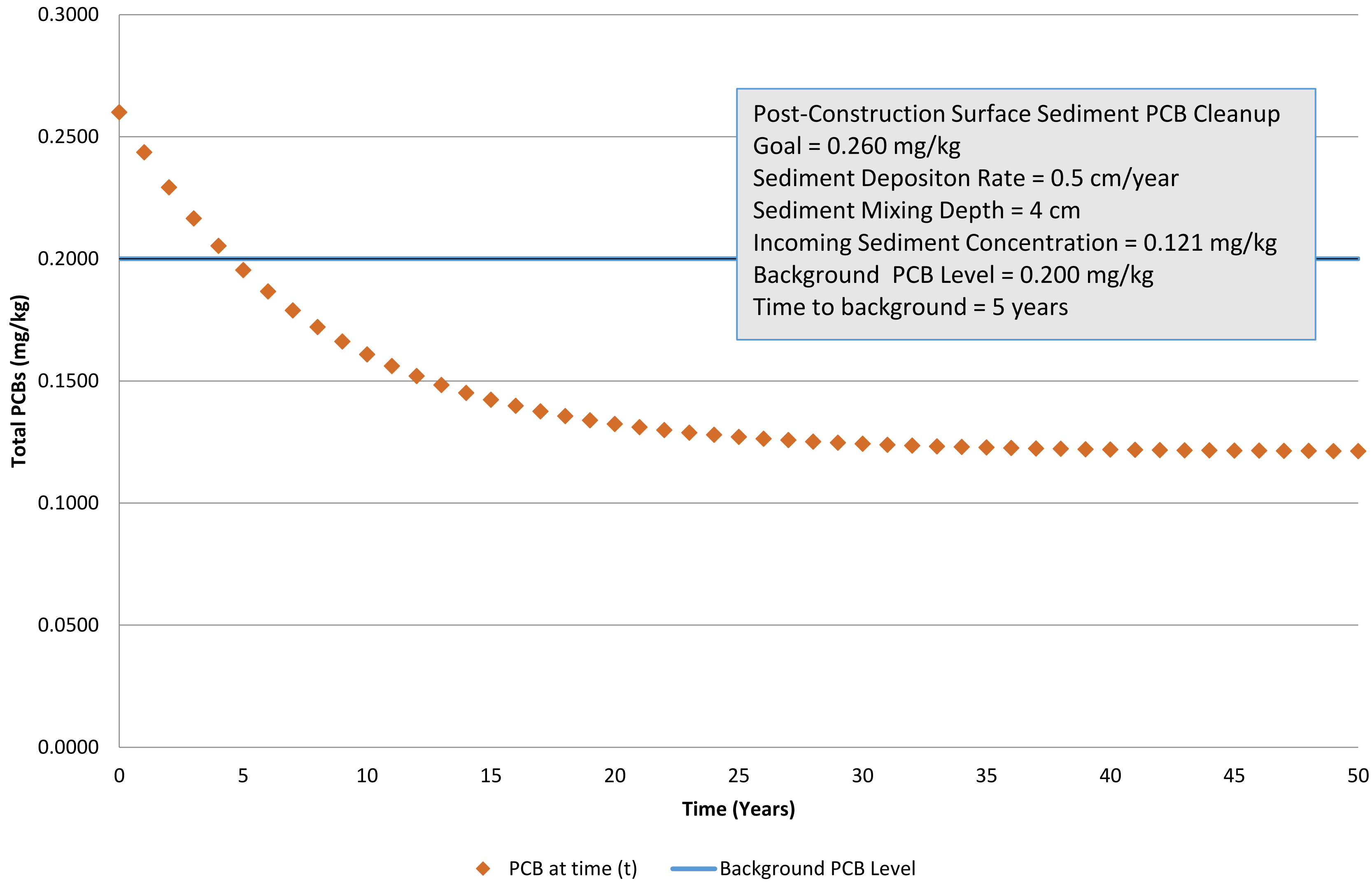

Figure 5
Reduction in HPNS Sediment PCB Level due to MNR (Area X)